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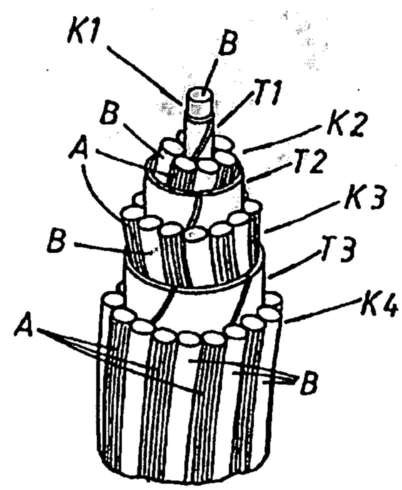
(54) Title: CONDUCTOR FOR HIGH-VOLTAGE WINDINGS AND A ROTATING ELECTRIC MACHINE COMPRISING A WINDING INCLUDING THE CONDUCTOR

(57) Abstract

The invention relates to a conductor for high-voltage windings, preferably for use in the stator of a high-voltage generator, which is designed to ensure uniform current distribution, to counteract eddy-current losses and to ensure that the inner semiconducting layer of the insulation system has the same potential during operation as the strand layers (K1-K4). This is achieved by the electrical insulation between the strands being such that only certain strands (A) are clad with an electrically insulating layer. The outermost layer of strands (K4) shall have at least one uninsulated strand (B). The invention also relates to a rotating electric machine comprising a conductor in accordance with the above.



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CONDUCTOR FOR HIGH-VOLTAGE WINDINGS AND A ROTATING ELECTRIC MACHINE COMPRISING A WINDING INCLUDING THE CONDUCTOR

TECHNICAL FIELD OF THE INVENTION

The present invention relates to conductors for high-voltage windings, preferably for the high-voltage windings of the stator in a high-voltage generator, which conductors are stranded with two or more layers of strands electrically insulated from each other, around a central core, which core may be one of the strands of the conductor, air or other material.

The invention also relates to a rotating electric machine according to the introductory part of claim 13 or, alternatively, claim 20.

The rotating electrical machines referred to in this context are e.g. synchronous machines, but also double-fed machines, applications in asynchronous static current converter cascades, outerpole machines and synchronous flux machines as well as alternating current machines intended primarily as generators in a power station for generating electric power are referred to.

The magnetic circuit referred to in this context comprises a magnetic core of laminated, non-oriented or oriented, sheet or other material, for example amorphous or powder-based, or any other arrangement for the purpose of allowing an alternating magnetic flux, a winding, a cooling system, etc., and which may be arranged in the stator of the machine, in the rotor or in both.

BACKGROUND OF THE INVENTION

The stator winding in known generators traditionallly consists of an electric conductor comprising a number of insulated rectangular wires, also known as strands, of copper, aluminium

or other suitable metal. These strands are transposed (i.e. change place with each other) and are surrounded by a common insulation in such a way that the bundle of conductors acquires a rectangular cross section. The copper conductors are rectangular in order to reduce the eddy-current losses (the linear dimension in the direction of the magnetic field shall be small). However, a conductor with rectangular cross section in a high-voltage insulation (i.e. in a conductor) has the disadvantage that it provides much greater field strength at the corners of the conductor, the corners thus becoming dimensioning for the thickness of the insulation. Therefore, from the point of view of optimal insulation thickness, circular conductors would be preferable.

Circular conductors can be constructed in a great number of different ways. The conductor may, for instance, consist of:
1) a solid rod of copper or other metal with circular cross section,
2) a conductor stranded from circular wires having the same or different diameters,
3) a conductor stranded from sectioned wires,
4) a conductor compressed from a number of segments, each of which is in turn stranded from circular wires and then formed into a segment.

In order to reduce the conductor dimension it is sometimes compressed or compacted after stranding, thereby altering the shape of the strands in the outermost layer or in the whole conductor, which may costitute a disadvantage.

To ensure high energy transfer in voltage-transmission lines with a conductor for a given voltage, the current must be increased, which is only possible if the conductor area is increased. When the current becomes large this entails the drawback that the current distribution in the conductor becomes uneven (the current endeavours to reach the outer

surface of the conductor) and what is known as a "skin effect", current pinch effect, is obtained. To counteract this, conductors , according to prior art, having large cross section (> 1200 mm^2 Cu) are produced, usually called Millikan conductors, i.e. conductors built up of a number of concentrically arranged wires which have subsequently been compressed and shaped. Such a conductor is often composed of 5 or 7 segments which are in turn insulated from each other. Such a construction is effective in reducing current pinch effect in transmission and distribution cables for high-voltage.

It is previously known that, in distribution systems for high-voltage power transmission all the strands in the cable have been insulated with varnish, for instance, in order to reduce the current pinch effect, see the publication Hitachi Cable Review, No. 11, August 1992, pages 3 - 6: "An EHV Bulk Power Transmission Line Made with Low Loss XLPE Cable". This publication also describes how a few of the strands in the outermost layer are left uninsulated in order to prevent differences in potential between the wire strands and the inner semi-conductor layer. No application of this technology on generator windings, however, is described.

With generators having conventionally designed stator windings as described above, the upper limit for generated voltage has been deemed to be 30 kV. This usually means that a generator must be connected to the power network via a transformer which steps up the voltage to the level of the power network, - in the range of 130-400 kV.

During the last decades, there have been increasing demands for rotating electric machines for higher voltages than what has previously been possible to design. The maximum voltage level which, according to the state of the art, has been possible to achieve for synchronous machines with a good yield

in the coil production is around 25-30 kV. It is also commonly known that the connection of a synchronous machine/generator to a power network must take place via a Δ/Y-connected so-called step-up transformer, since the voltage of the power network normally lies at a higher level than the voltage of the rotating electric machine. Thus, this transformer, and the synchronous machine, constitute integral parts of an installation. The transformer constitutes an extra cost and also has the disadvantage that the total efficiency of the system is reduced. If it were possible to manufacture machines for considerably higher voltages, the step-up transformer could thus be omitted.

Attempts to develop the generator for higher voltages have, however, been in progress for a long time. This is obvious, for instance from "Electrical World", October 15, 1932, pages 524-525. This describes how a generator designed by Parson 1929 was arranged for 33 kV. It also describes a generator in Langerbrugge, Belgium, which produced a voltage of 36 kV. Although the article also speculates on the possibility of increasing voltage levels still further, the development was curtailed by the concepts upon which these generators were based. This was primarily because of the shortcomings of the insulation system where varnish-impregnated layers of mica oil and paper were used in several separate layers.

Certain attempts to a new approach as regards the design of synchronous machines are described, inter alia, in an article entitled "Water-and-oil-cooled Turbogenerator TVM-300" in J. Elektrotechnika, No. 1, 1970, pp. 6-8, in US 4,429,244 "Stator of Generator" and in Russian patent document CCCP Patent 955369.

The water- and oil-cooled synchronous machine described in J. Elektrotechnika is intended for voltages up to 20 kV. The article describes a new insulation system consisting of

oil/paper insulation, which makes it possible to immerse the stator completely in oil. The oil can then be used as a coolant while at the same time using it as insulation. To prevent oil in the stator from leaking out towards the rotor, a dielectric oil-separating ring is provided at the internal surface of the core. The stator winding is made from conductors with an oval hollow shape provided with oil and paper insulation. The coil sides with their insulation are secured to the slots, made with rectangular cross section, by means of wedges. As coolant, oil is used both in the hollow conductors and in holes in the stator walls. Such cooling systems, however, entail a large number of connections for both oil and electricity at the coil ends. The thick insulation also entails an increased radius of curvature of the conductors, which in turn results in an increased size of the winding overhang.

The above-mentioned US patent relates to the stator part of a synchronous machine which comprises a magnetic core of laminated sheet with trapezoidal slots for the stator winding. The slots are tapered since the need of insulation of the stator winding is smaller towards the interior of the rotor where that part of the winding which is located nearest the neutral point is disposed. In addition, the stator part comprises a dielectric oil-separating cylinder or ring nearest the inner surface of the core which may increase the magnetization requirement relative to a machine without this ring. The stator winding is made of oil-immersed cables with the same diameter for each coil layer. The layers are separated from each other by means of spacers in the slots and secured by wedges. What is special for the winding is that it comprises two so-called half-windings connected in series. One of the two half-windings is disposed, centred, inside an insulation sleeve. The conductors of the stator winding are cooled by surrounding oil. The disadvantage with such a large quantity of oil in the system is the risk of leakage and the

considerable amount of cleaning work which may result from a fault condition. Those parts of the insulation sleeve which are located outside the slots have a cylindrical part and a conical termination reinforced with current-carrying layers, the purpose of which is to control the electric field strength in the region where the cable enters the end winding.

From CCCP 955369 it is clear, in another attempt to raise the rated voltage of the synchronous machine, that the oil-cooled stator winding comprises a conventional insulated conductor for medium voltage with the same dimension for all the layers. The conductor is placed in stator slots formed as circular, radially disposed openings corresponding to the cross-section area of the cable and with the necessary space for fixation and for coolant. The different radially disposed layers of the winding are surrounded by and fixed in insulated tubes. Insulating spacers fix the tubes in the stator slot. Because of the oil cooling, an internal dielectric ring is also needed here for sealing the coolant against the internal air gap. The design shown has no tapering of the insulation or of the stator slots. The design exhibits a very narrow radial waist between the different stator slots, which means a large slot leakage flux which significantly influences the magnetization requirement of the machine.

In a report from the Electric Power Research Institute, EPRI, EL-3391 from April 1984, an account is given of generator concepts for achieving higher voltage in an electric generator with the object of being able to connect such a generator to a power network without intermediate transformers. Such a solution is assessed in the report to offer good gains in efficiency and considerable financial advantages. The main reason that it was deemed possible in 1984 to start developing generators for direct connection to power networks was that a supra-conducting rotor had been developed at that time. The considerable excitation capacity of the supra-conducting field

enables the use of airgap-winding with sufficient thickness to withstand the electrical stresses.

By combining the concept deemed most promising according to the project, that of designing a magnetic circuit with winding, known as "monolith cylinder armature", a concept in which two cylinders of conductors are enclosed in three cylinders of insulation and the whole structure is attached to an iron core without teeth, it was assessed that a rotating electric machine for high-voltage could be directly connected to a power network. The solution entailed the main insulation having to be made sufficiently thick to withstand network-to-network and network-to-ground potentials. Obvious drawbacks with the proposed solution, besides its demand for a supra-conducting rotor, are that it also requires extremely thick insulation, which increases the machine size. The coil ends must be insulated and cooled with oil or freons in order to control the large electric fields at the ends. The whole machine must be hermetically enclosed in order to prevent the liquid dielectric medium from absorbing moisture from the atmosphere.

SUMMARY OF THE INVENTION

The object of the present invention is to solve the above mentioned problems and to provide a rotating electric machine which permits direct connection to all types of high-voltage power networks.

This object is achieved by providing a conductor for high-voltage windings, as defined in the introductory part of claim 1, with the advantageous features of the characterizing part of said claim, and by providing a rotating electric machine in accordance with the introductory of claim 13 or claim 20 with the advantageous features of the characterizing parts of said claims, respectively.

Accordingly, the electrical insulation between the strands of the conductor is made such that only certain strands are clad with an electrically insulating layer, said strands which are provided with an insulating layer being so situated within the layers of the conductor that no two uninsulated strands come into electrical contact with each other.

Preferably, the electric conductor according to the invention comprises a number of twisted layers consisting of strands, of copper, aluminium or other suitable metal. However, contrary to conventional conductors for power transmission, the electrically conducting layer of the conductor is subjected to a magnetic field which induces currents, resulting in losses. In order to reduce these losses, therefore, the strands must be insulated from each other, but the requirement still remains that at least some strand in the outermost layer shall be in contact with an inner semiconducting layer in the conductor's insulation. Therefore, the conductor is further characterized in that at least one strand in the outermost strand layer is uninsulated.

The uninsulated strand or strands in the outer layer of the conductor defines the potential on the inner semiconducting layer and thereby the advantage is achieved that it ensures a uniform electric field within the insulation. By using uninsulated strands instead of insulated strands is also achieved the advantage of obtaining a less expensive insulated conductor for a winding.

As yet another advantageous feature the present invention is characterized in that only a minority of said strands are being uninsulated from each other.

As regards the rotating electric machine according to the present invention, it is characterized in that the winding comprises at least one current-carrying conductor as claimed

in any one of the preceding claims, that a first layer having semiconducting properties is provided around said conductor, that a solid insulating layer is provided around said first layer, and that a second layer having semiconducting properties is provided around said insulating layer.

Preferably, a rotating electric machine according to the present invention comprises a high-voltage insulated conductor/cable with a central electric conductor, also according to the present invention, comprising a number of strands of copper (Cu), for instance, usually having a circular cross section. These strands are arranged in the middle of the high-voltage cable. Around the strands is a first semiconducting layer, and around the first semiconducting layer is an insulating layer, e.g. crosslinked polyethylene (XLPE) insulation. Around the insulating layer is a second semiconducting layer. Thus, in the present case, the concept "high-voltage cable" normally used to denote a winding in a rotating electric machine does not include the outer protective sheath that normally surrounds such cables for power distribution. Furthermore, in a high-voltage cable for power distribution there is also an outer insulating layer on top of the second semiconducting layer, which is not included here.

By using conductors, of substantially the same type as conductors for transferring electric power, in the stator winding of the generator, in accordance with the invention, the advantage is achieved that the voltage of the machine is increased to such a level that it can be connected directly to the power network without intermediate transformers.

A rotating electric machine as defined in claim 13 or claim 20 has the advantage that it is possible to have at least one winding system of conductors suitable for direct connection to distribution or transmission networks.

This also entails the further important advantage that the Δ/Y-connected step-up transformer mentioned above can be omitted. Consequently, the solution according to the present invention represents major savings both in economic terms and regarding space requirement and weight for generator plants and other installations comprising rotating electric machines.

To be able to cope with the problems which arise in case of direct connection of rotating electric machines to all types of high-voltage power networks, a machine according to the invention may have a number of features which significantly distinguishes it from the state of the art both as regards conventional mechanical engineering and the mechanical engineering which has been published during the last few years. Some will follow below.

As mentioned, the winding is manufactured from one or more insulated conductors with an inner and an outer semiconducting layer, preferably an extruded cable of some sort. Some typical examples of such conductors are a cable of crosslinked polyethylene (XLPE) or a cable with ethylene propylene (EP) rubber insulation, which, however, for this purpose and according to the invention, has an improved design both as regards the strands of the conductor and as regards the outer layer.

The conductor is provided with an outer semiconducting layer with the aid of which its potential in relation to the surroundings shall be defined. This layer must therefore be connected to ground, at least somewhere in the machine, possibly only in the coil-end section.

The use of an insulated conductor with an outer semiconducting layer has the advantage that it permits the outer layer of the winding, in its full length, to be maintained at ground

potential. Consequently, the claimed invention may have the feature that the outer semiconducting layer is connected to ground potential. As an alternative, the outer layer may be cut off, at suitable locations along the length of the conductor, and each cut-off part length may be directly connected to ground potential.

A considerable advantage with having the outer layer connected to ground potential is that the electric field will be near zero in the coil-end region outside the outer semiconductor and that the electric field need not be controlled. This means that no field concentrations can be obtained, neither within the sheet, nor in the coil-end region, nor in the transition therebetween.

As another advantageous feature at least two, and preferably all three, of the layers have substantially equal thermal expansion coefficients. Through this is achieved that thermal movement is prevented and the occurrence of cracks, fissures or other defects in the winding due to thermal movement is avoided.

According to another characterizing feature each of the three layers is solidly connected to the adjacent layer along substantially the whole connecting surface. This has the advantage that the layers are fixed and unable to move in relation to each other and serves to ensure that no play occurs between the layers. It is very important that no air is allowed to enter in-between the layers since that would lead to disturbances in the electric field.

As mentioned, the present invention is intended for use at high voltages, which here refers primarily to voltages in excess of 10 kV. A typical operating range for a device according to the invention may be voltages from 36 kV up to 800 kV, preferably in the range 72,5 - 800 kV. In addition,

the invention has the advantage to ensure uniform current distribution, counteract eddy-current losses and ensure that the inner semiconducting layer of the insulation system has the same potential during operation as the wire or strand layers in the conductor.

The material requirements for the insulating layer with regard to the XLPE process, for instance, are that it shall be stable, will not melt and is resistant to deformation at temperatures up to 220^{o}C for approximately 30 min. Examples are enamelled wire, powder sintering (epoxy, high-temperature plastic), extruded high-temperature plastic, oxide layers.

The above-mentioned object of the present invention is optimized by the various embodiments of the construction of the conductor, as expressed in the dependent claims. Further features and advantages will therefore be apparent from the remaining dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The conductor for the stator winding in a high-voltage generator according to the present invention will be illustrated further in the following description of a number of embodiments by way of example, with reference to the accompany drawings in which

- Figure 1 shows an embodiment of a conductor according to the invention with strands arranged concentrically in layers with different stranding direction,
- Figure 2 a second embodiment of the conductor according to the invention with strands arranged concentrically in layers insulated from each other with insulating tape inserted between the layers,
- Figure 3 shows an embodiment of the conductor according to the invention similar to that in Figure 1, but in which the strands have been arranged in the same direction, and

- Figure 4 is a cross section through an insulated conductor or cable including a central conductor according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows an example of a conductor according to the invention with circular strands A and B having uniform cross section, which have been arranged concentrically. The strand layers K1, K2, K3 and K4 are arranged with alternating stranding direction. The strands A, shaded in the drawings, are electrically insulated, whereas the strands B (not shaded in the drawings) are electrically uninsulated. Thus alternate strands (B) in alternate strand layers K2, K4 are uninsulated. In the conductor illustrated, comprising layers comprising 1+6+12+18 strands A+B, thus, 9 strands B in the outer layer K4 and 3 strands B in the layer K2 next to the innermost layer are uninsulated, i.e. 12 strands out of 37 are uninsulated.

Figure 2 shows another embodiment of the conductor according to the invention by way of example. As with the conductor according to Figure 1, circular strands A and B with uniform cross section are arranged concentrically. As in Figure 1 the strand layers K1, K2, K3 and K4 are arranged in alternating directions. The strands A (shaded in the drawings) are insulated, whereas the strands B (not shaded in the drawings) are uninsulated. Thus alternate strands in all the strand layers are uninsulated. The strand layers K1, K2, K3 and K4 are insulated from each other by means of a tape T1, T2 and T3, respectively, inserted between the strand layers and consisting either of a tape running longitudinally in the conductor or, as shown in Figure 2, a tape being spun between the layers. On the totally 37 strands A+B 19 strands B are uninsulated here. The tapes T1, T2, T3 may be of paper or other insulating material.

The tape T1 may of course be omitted if the single strand in strand layer K1 is insulated.

Figure 3 shows a conductor built up in accordance with that in Figure 1 with the exception that the strand layers K2, K3 and K4 are stranded in the same direction.

Figure 4 shows a cross-sectional view of a high-voltage cable 10 including a central conductor 1 according to the present invention. This cable is not identical with what is normally intended by the expression "high-voltage cable", as is explained below. A more relevant expression may be "insulated conductor", but in order to distinguish the insulated conductor from the (central) conductor of the invention, the expression "cable" may be used. It should be stressed that whenever only the expression "conductor" is used in the present application, this does not pertain to the cable or insulated conductor, but to the conductor element in the centre of the cable.

In figure 4, the high-voltage cable comprises the (central) conductor 1 including a number of strands A,B of copper (Cu), for instance, having circular cross section. These strands A,B are arranged in the middle of the high-voltage cable. Around the strands A,B is a first semiconducting layer 2, and around the first semiconducting layer 2 is an insulating layer 3, e.g. XLPE insulation. Around the insulating layer 3 is a second semiconducting layer 4. Thus the concept "high-voltage cable" in the present application does not include the outer protective sheath that normally surrounds such cables for power distribution. As regards the geometric dimensions of the insulated conductor or cable the conductor area is comprised in the approximate interval of 80 - 3000 mm^2 and the outer diameter is in the approximate interval of 20 - 250 mm.

The conductor according to the invention may of course be made up of more or fewer strand layers depending on the demands placed on the conductor in the stator winding of the generator. It is also possible to make the strand layers out of pre-shaped strands, in which case the cross section of the conductors can be minimized. In other variations the conductor according to the invention may have strands with different cross section in the various layers. In order to achieve a uniform cross section between the insulated strands A and the uninsulated strands B, the electrically conducting area of the insulated strands A may be less than the area of the uninsulated strands B.

Although copper is the most efficient material for the strands A and B in the conductor, other electrically conducting materials such as aluminium are also feasible. The strands in different layers may be of different electrically conducting material.

It is also feasible for the insulated strands A to consist of aluminium, the surface of which is oxidized and thus provides the requisite insulation.

Minimization of the eddy current losses is achieved by ensuring that the strands used in the finished conductor according to the invention do not have a linear dimension exceeding 4 mm, preferably < 2 mm. A condition for the potential on the conducting strand layers being the same as on the inner semiconducting layer of the conductor during operation is that the outer layer of strands K4 has at least one uninsulated strand B, which is thus in electrical contact with the semiconducting layer (not shown in the drawings). Examples are enamelled wire, eddy sintering, extrusion, oxide layer.

Patent claims

1. A conductor for high-voltage windings, **characterized** in that saidconductor being stranded with two or more layers (K1 - K4) of strands (A) electrically insulated from each other, around a central core, which core may be one of the strands (A or B) of the conductor, air or other material, and thatthe electrical insulation between the strands is such that only certain strands (A) are clad with an electrically insulating layer, and that said strands (A) are provided with an insulating layer being so situated within the layers (K1- K4) of the conductor that no two uninsulated strands (B) come into electrical contact with each other.

2. A conductor as claimed in claim 1, **characterized** in that at least one strand in the outermost layer (K4) is uninsulated.

3. A conductor as claimed in claim 2, **characterized** in that the conductor is formed by circular strands being arranged concentrically with alternating stranding direction, at least one strand (B) being uninsulated in the outermost layer (K4).

4. A conductor as claimed in claim 2, **characterized** in that the conductor is formed by circular strands being arranged concentrically with alternating stranding direction, and that alternate strands (B) in alternate layers (K2, K4) are uninsulated.

5. A conductor as claimed in claim 2, **characterized** in that the conductor is formed by circular strands being arranged concentrically with alternating stranding direction, wherein alternate strands (B) in all the layers (K1 - K4) are insulated and the layers per se are insulated from each other by insulating tape (T1 - T3).

6. A conductor as claimed in claim 5, **characterized** in that the tape (T1 - T3) is arranged longitudinally along the layers (K1 - K4) in the conductor or spun between the layers (K1 - K4) in the conductor.

7. A conductor as claimed in claim 5 or claim 6, **characterized** in that the tape (T1 - T3) is of paper or synthetic material.

8. A conductor as claimed in any of claims 3-5, **characterized** in that the strands (A, B) have a pre-shaped cross section.

9. A conductor as claimed in any of the preceding claims, **characterized** in that the layers (K1 - K4) of strands (A, B) have been arranged in the same direction.

10. A conductor as claimed in any of the preceding claims, **characterized** in that the linear dimension of the strand (A, B) used is maximally 4 mm, preferably however limited to 2 mm.

11. A conductor as claimed in any of the preceding claims, **characterized** in that the insulated strands (A) are aluminium wires provided with an insulating oxide layer and the other strands (B) are uninsulated copper or aluminium wires.

12. A conductor as claimed in any one of the preceding claims, **characterized** in that only a minority of the strands are being uninsulated from each other.

13. A rotating electric high-voltage machine comprising a stator, a rotor and at least one winding, **characterized** in that said winding comprises at least one current-carrying conductor (1) as claimed in any one of the preceding claims, that a first layer (2) having semiconducting properties is provided around said conductor, that a solid insulating layer (3) is provided around said first layer, and that a second

layer (4) having semiconducting properties is provided around said insulating layer.

14. A rotating electric machine according to claim 13, **characterized** in that the potential of said first layer (2) is substantially equal to the potential of the conductor (1).

15. A rotating electric machine according to claim 13 or 14, **characterized** in that said second layer (4) is arranged to constitute a substantially equipotential surface surrounding said conductor.

16. A rotating electric machine according to claim 15, **characterized** in that said second layer is connected to a predetermined potential.

17. A rotating electric machine according to claim 16, **characterized** in that said predetermined potential is ground potential.

18. A rotating electric machine according to any one of claims 13-17, **characterized** in that at least two adjacent layers have substantially equal thermal expansion coefficients.

19. A rotating electric machine according to any one of claims 13-18, **characterized** in that each of said three layers (2,3,4) is solidly connected to the adjacent layer along substantially the whole connecting surface.

20. A rotating electric machine having a magnetic circuit for high-voltage comprising a magnetic core and a winding, **characterized** in that said winding is formed of a cable (10) comprising at least one current-carrying conductor (1) according to any one of claims 1-12, that each conductor comprises a number of strands (A,B), that an inner semiconducting layer (2) is provided around each conductor,

that an insulating layer (3) of solid insulating material is provided around said inner semiconducting layer, and that an outer semiconducting layer (4) is provided around said insulating layer.

21. A rotating electric machine according to any one of claims 13-20, **characterized** in that said winding also comprises a metal shield and a sheath.

- - - - -

Fig.1

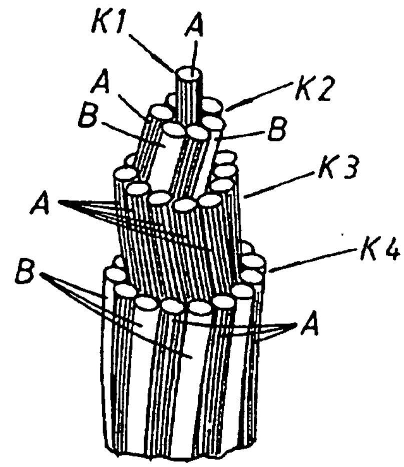


Fig.2

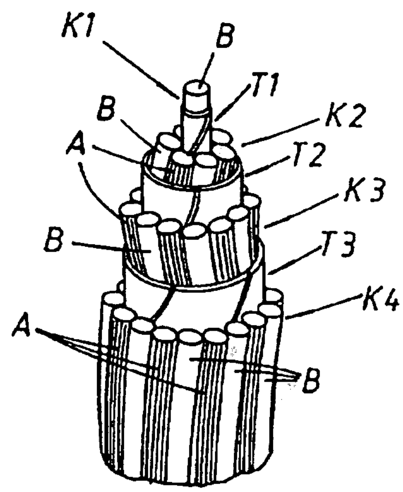
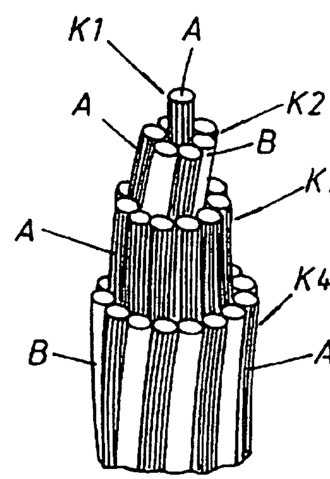


Fig.3



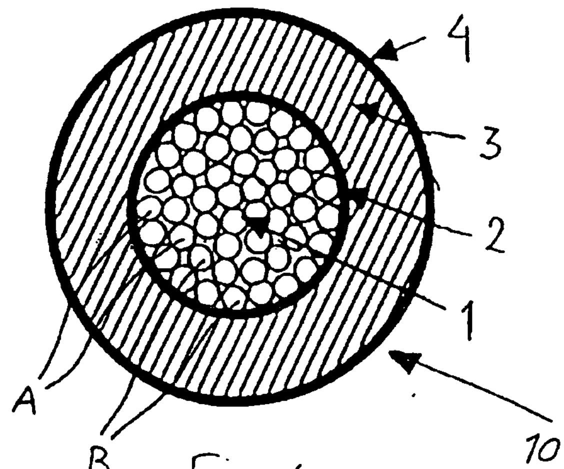


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00902

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 3/40, H02K 15/08, H01B 7/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K, H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI,CLAIMS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5094703 A (MICHKIO TAKAOKA ET AL), 10 March 1992 (10.03.92), column 5, line 3 - column 58, figures 7-11, abstract	1-4,8-12
A		3-7,13-21
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Y	US 4692731 A (HALBE OSINGA), 8 Sept 1987 (08.09.87), column 3, line 52 - column 4, line 44, figures 1,3, abstract	1-4,8-12
A		3-7,13-21
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A	US 4546210 A (YUTAKA AKIBA ET AL), 8 October 1985 (08.10.85), column 2, line 37 - line 56, figure 4, abstract	1-21
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" erlier document but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 August 1997	11-09-1997

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00902

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0695019 A1 (INDUSTRIE MAGNETI MARELLI S.P.A.), 31 January 1996 (31.01.96), figure 3, abstract --	13-21
A	SE 453236 B (ELIN-UNION AG FüR ELEKTRISCHE INDUSTRIE), 18 January 1988 (18.01.88), figure 1, abstract --	13-21
A	US 4109098 A (MATS GUNNAR OLSSON ET AL), 22 August 1978 (22.08.78), abstract -- --------	1-21

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Information on patent family members

06/08/97

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06/08/97

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